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THE OPPORTUNITY TO THIN AND PRUNE in the NORTHERN ROCKY MOUNTAIN AND INTERMOUNTAIN REGIONS

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
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REED W. BAILEY, DIRECTOR

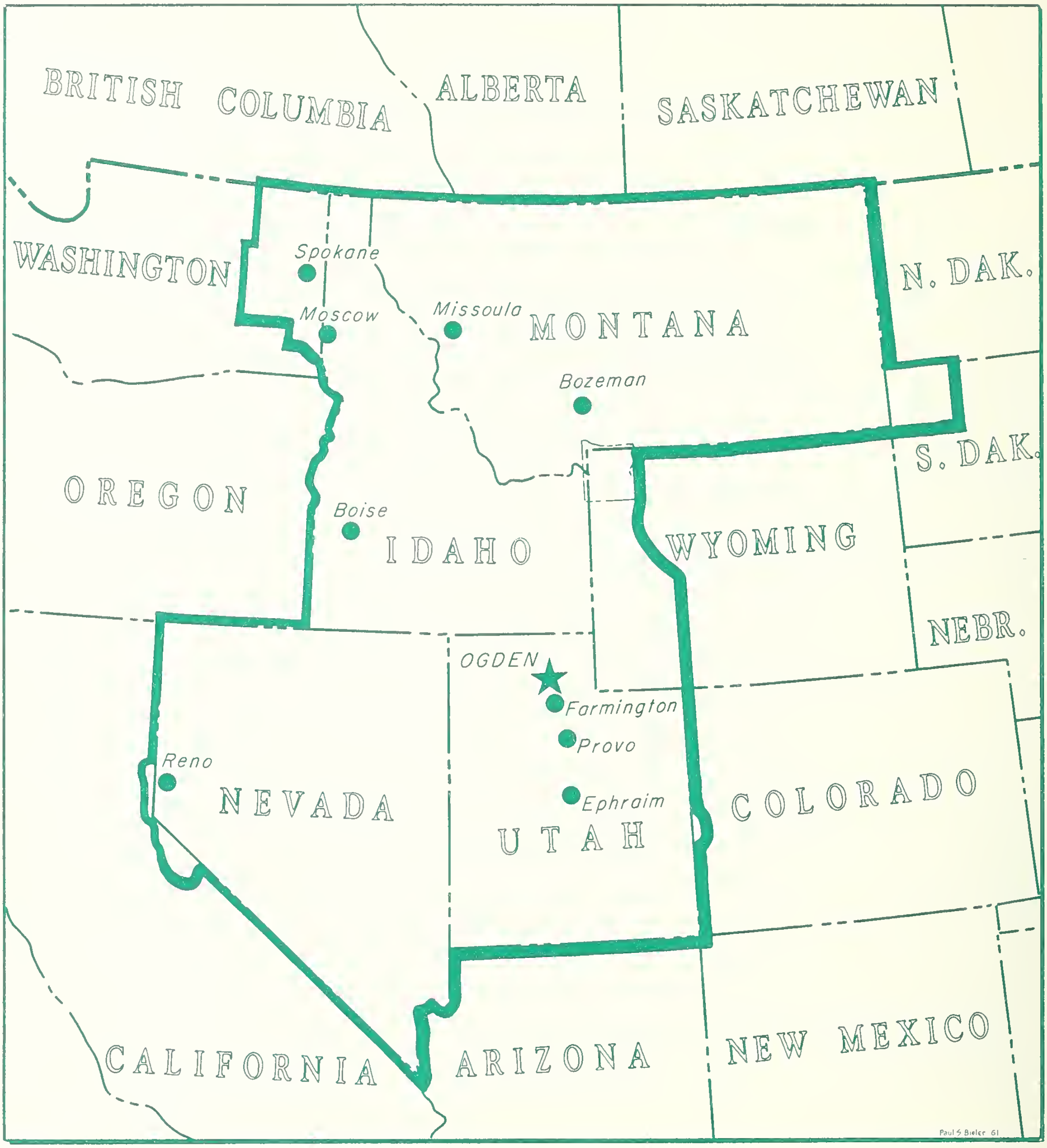

Figure 1.—The Northern Rocky Mountain and Intermountain regions.

THE OPPORTUNITY TO THIN AND PRUNE IN THE NORTHERN ROCKY MOUNTAIN AND INTERMOUNTAIN REGIONS

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Contents

FOREWORD

This is the first of two reports presenting the findings of an economic study of timber growing and timber industry development undertaken at the request of the Northern Region of the U. S. Forest Service. This publication, by John H. Wikstrom and Charles A. Wellner, points out and evaluates the opportunities for thinning and pruning in the Northern Rocky Mountain and Intermountain Regions.

A second publication will discuss management possibilities and the problem of developing adequate management programs on the national forests of the Clark Fork Timber Development Unit in western Montana.

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INTRODUCTION

Thinning and pruning do not have high priority in Northern Rocky Mountain or Intermountain forestry today.[1] This situation arises largely from inadequate financing. Partly, however, it stems from a state of mind that has only recently begun to change. Thinning and pruning have been thought of only as a part of intensive forestry, that is the kind of extra activity that might be used someday to expand forest productivity—but not yet; not today.

One can hardly argue against the idea that thinning and pruning represent considerably more intensive forestry than is being practiced today in these two regions; yet there is some question whether these practices can be long postponed without a costly sacrifice of future timber yields and values. In this light, thinning and pruning cease to be refinements or frills and become a basic part of forestry in these regions. This conclusion is supported by three facts about our regional forestry situation:

- First is the fact that most of the timber types in these regions tend to overstock. Much of our attention until now has been directed toward the more conspicuous problem of understocking, and relatively little toward the problem of overdenseness. Yet, this latter problem is far more serious than most people realize. Unless we deal effectively with the matter of sheer numbers of trees, the very prolificness of nature will sharply limit future timber yields. Conversely, the yields possible by opening up young stands with thinning will be truly startling to persons conditioned to the low productivity of overstocked natural stands so common in the area.
- Second is the fact of limb persistence, which discounts quality. Encouraged by a cool, dry climate that inhibits decay, branches tend to remain on trees long after they have died. It will be impossible to produce a high percentage of surface-clear logs and maintain timber quality in the relatively short rotations we are contemplating for the future unless branches are removed artificially from the lower boles.
- Third is the fact that operating and management costs in this locality, like the altitude, tend to be high. To keep forestry competitive, these high costs must be offset by high yields.

Purpose and Scope

The purpose of this report is to describe the impact of overcrowding and limb persistence and to indicate the emphasis thinning and pruning should have in the Northern Rocky Mountain and Intermountain States. This analysis is not from the usual point of view of treating thinning and pruning as investments in individual trees or acres. Rather, it examines the broader effect of thinning and pruning on the level of yield and financing in the total forestry operation. This report considers:

- The impact of overstocking.
- The impact of limb persistence.
- The case for thinning and pruning as a means of reducing the cost of producing wood.

For this report, we have relied heavily on data from western Montana because they are available and also because statistics for this area cover a wide range of site conditions. Because the data take account of site, they should be applicable anywhere in the Intermountain and Northern Rocky Mountain Regions where such sites occur.

Framework of this Analysis

The discussion in this paper relates to thinning done at the proper stage in the development of young stands; that is, in stands that have not been allowed to become overcrowded and lose vigor. Millions of acres in the Northern Rocky Mountain and Intermountain Regions support timber that has grown beyond the ideal stage to start thinning. No doubt these older, overcrowded stands present the most serious management problem we face. To thin in them would be very expensive. The cost could run as high as $80 per acre. At the same time, response to thinning in many of these stands would be very slow. Just how these older stands should be handled involves considerations that go beyond the scope of this paper. Those stands that have stagnated to the point where they will never produce usable products no doubt will have to be destroyed to make room for new trees, and the quicker this is done, the better. Some of these older stands may contain enough volume that it would be worthwhile to hold them in a hope a market will develop, even though it means carrying them far beyond rotation age. It may be necessary to thin the more vigorous stands in this category, even though the thinning operation itself is a losing proposition, in order to balance out the age class distribution and allowable cut.

However, these are all problems to be worked out later. The more immediate problem is to determine to what extent thinning can stop any more stands from falling into this overcrowded, low-vigor category from which only low per-acre yields can be expected. Also, there is a need to determine to what extent pruning might complement thinning as a means to improve value yields in such stands. It is toward these problems that our study is directed.

[1]Figure 1 (inside front cover) outlines the Northern Rocky Mountain and Intermountain Regions, in which this Experiment Station conducts research.

THE IMPACT OF OVERCROWDING

Most timber-inventory systems classify a stand with a closed canopy as "fully stocked" and by implication as "desirable." Yet many fully stocked stands in the Northern Rocky Mountain and Intermountain Regions are seriously overcrowded. In some stands, a closed canopy is associated with a situation worse than no trees at all—total growth capacity has been dissipated on so many stems that few, if any, will grow big enough to be usable (fig. 2).

Figure 2.—This stagnated stand of lodgepole pine 60 years old averages less than 2 inches d. b. h.

A Common Condition

Data from the Forest Service's Timber Resource Review[2] show that 36 percent of the young forest in the Mountain States is well stocked, and 34 percent medium stocked. The stocking profile by types for western Montana,[3] which is pictured in figure 3, is more or less typical of the situation throughout the Northern Rocky Mountain and Intermountain Regions. Except in the ponderosa pine and alpine fir types, well-stocked stands predominate, and medium- and well-stocked stands combined occupy the lion's share of the area. The Mountain West[4] has relatively little poorly stocked forest.

The stocking situation, however, is considerably less satisfactory than this classification implies. Probably no more than a handful of the so-called "well-stocked" stands are properly stocked. Most stands contain too many trees for truly effective growth.

Overstocking is not confined to the well-stocked stands. Odd as it may seem, it also occurs in stands that by definition are medium or poorly stocked. This anomaly arises from the fact that stocking as measured by the Forest Survey is only an indication of the percentage of the area in a stand that is occupied by trees. It does not tell how the trees are distributed over the area they occupy. Thus, many stands classed as medium or poorly stocked consist of overdense clumps of trees intermixed with areas having no trees at all.

The problem of superabundance is most strikingly evident in the lodgepole pine type where stand after stand has failed to produce crop trees

[2]U. S. Forest Service. Timber resources for America's future. 713 pp. Washington. 1958. P. 546.

[3]Montana, west of the Continental Divide.

[4]The 3 million acres of nonstocked forest land in the Intermountain and Northern Rocky Mountain Regions constitute a special problem not included in the scope of this report.

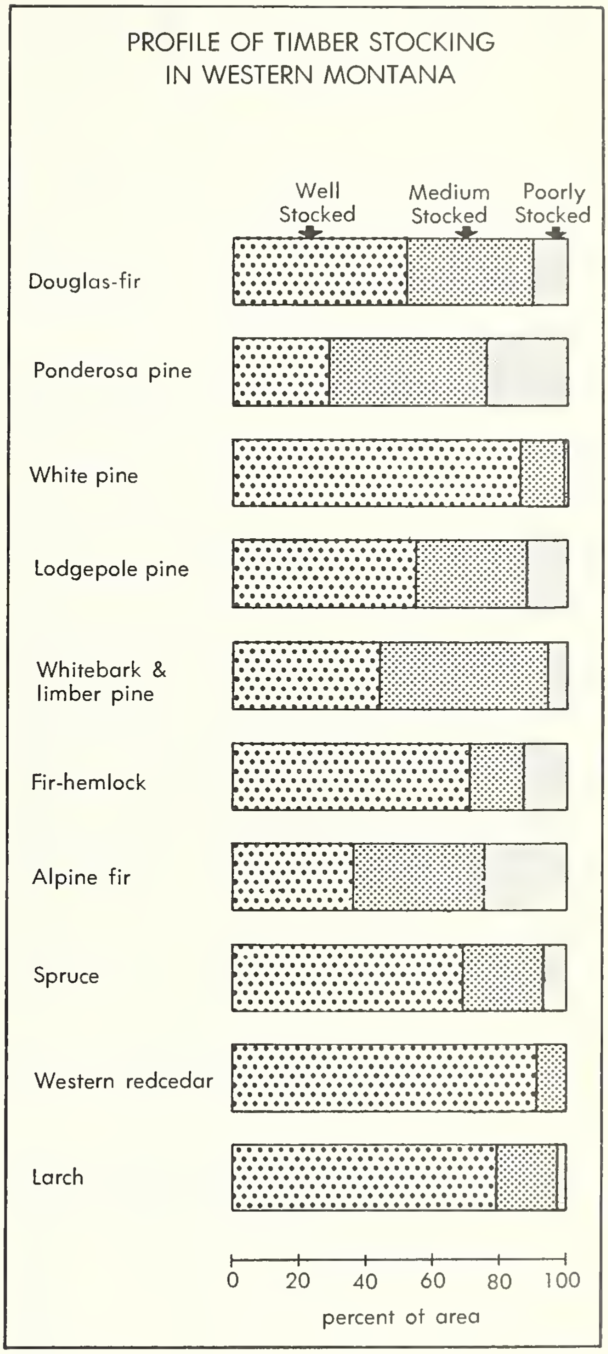
as big as 11 inches in diameter because total growth has been divided among too many stems. For example, in western Montana, fully half of the existing lodgepole pine stands will have to be written off insofar as 11-inch and larger trees are concerned, even though the sites they occupy have the capacity to produce trees of this size.

An even more serious aspect of the lodgepole pine problem is that a substantial part (28 percent) of the lodgepole pine seedling-sapling stands in western Montana are so overcrowded and stagnated that virtually no trees will ever reach a size large enough even for pulpwood. Lodgepole pine stands 100 years old with 10,000 or more stems per acre averaging less than 2 inches in diameter are not a rarity. Such stands waste the space they occupy.

The Opportunity for Thinning

One of the big problems in timber inventory in the Northern Rocky Mountain and Intermountain Regions today is to develop statistics that adequately measure the stocking situation. Until such statistics are available, we shall be handicapped in describing the management problem involved in maintaining proper space relationships. Nevertheless, we can pretty well measure the end effect of overstocking by comparing the volumes in present well-stocked rotation-age stands with the volumes these stands theoretically should have. Opportunities for improving yields of five important timber types in western Montana[5] are shown graphically by figure 4 and table 1. Figure 4 shows, for example, that on medium sites, well-stocked stands of rotation age have from 26 percent to 62 percent of the board-foot volume they might reasonably be expected to have if tree distribution were controlled.

Forest managers generally agree that total wood yields cannot be increased by thinning except in stands that will otherwise stagnate. In such stands, thinning will increase both the total yield and the yield of utilizable wood.



Source: Forest Survey data

Figure 3.

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[5]Theoretical yields were calculated by:

1. Discounting normal basal area for that type site and age by 25 percent.
2. Estimating from site tree data average diameters obtainable at rotation age if stocking were kept under control.
3. Computing the harvest volume if the discounted basal area were made up of trees of the average size obtainable with stocking control.

These calculations are more completely described in a mimeographed report, **Forest management objectives in western Montana,** October 14, 1959, Intermountain Forest and Range Experiment Station, Ogden, Utah.

The effect of thinning in nonstagnating stands is to concentrate the growth on fewer trees. This produces larger volumes of utilizable wood but does not increase total wood yield.

These comparisons describe both the problem of overstocking and the opportunity for thinning. The opportunity is substantial. For example, to raise medium-site lodgepole pine sawtimber yields at rotation age from 6,000 board feet per acre to 23,000 board feet per acre, or medium-site larch from 24,000 to 39,000 board feet per acre would be an important accomplishment.

The gains to be achieved by thinning are only partially expressed by volume estimates. The larger volumes would be realized through the more rapid growth of the individual tree which is significant in its own right. Table 2 indicates the average-size crop trees that could probably be achieved in stands where proper spacing is maintained throughout a rotation. These estimates appear realistic, as they are based on about 1,200 trees actually measured by the Forest Survey for site determination throughout western Montana and northern Idaho.[6] Site trees generally are chosen from the dominant and codominant trees in the stand, and usually have had a little more room to grow than their associates. It is reasonable to assume then that site trees are a fair indication of sizes that could be attained by all crop trees if they had adequate growing space.[7]

[6]Idaho, north of the Solmon river.

Toble 1.—**Sawtimber yields attainable in thinned stands compared with the current volume of well stocked rotation-age stands in western Montana**

Species and rotation period (years)	Poor site		Medium site		Good site	
	Thinned stands	Natural stands	Thinned stands	Natural stands	Thinned stands	Natural stands
	Thousand board feet per acre[1]					
Ponderosa pine (140)	13	4	27	10	49	19
Western larch (140)	20	13	39	24	58	41
Spruce (140)	25	15	49	26	73	(2)
Douglas-fir (140)	18	9	39	13	58	(2)
Lodgepole pine (120)	11	4	23	6	39	13
White pine (120)	35	(2)	51	22	70	33

[1]Trees 11.0 inches d.b.h. and larger.
[2]Insufficient data to establish average.
Source: Forest Survey

The size objectives shown in table 2 considerably exceed the actual performance of natural stands. For example, the 140 largest trees per acre in medium-site well-stocked lodgepole pine stands of rotation age in western Montana average about 10 inches in diameter in comparison with a size potential of 15 inches. The 100 largest trees in well-stocked rotation-age spruce stands in that area average 16 inches in comparison with a size potential of 22 inches.

[7]This is logicol for oll types thot grow in this oreo except lodgepole pine. Overcrowding is so generol in this type thot site trees do not offer odequote indicotion of potentiolities. For thot reoson, size objectives for lodgepole pine hod to be bosed on judgment ond locolized observotions in rore stonds where the trees hod odequote room to develop.

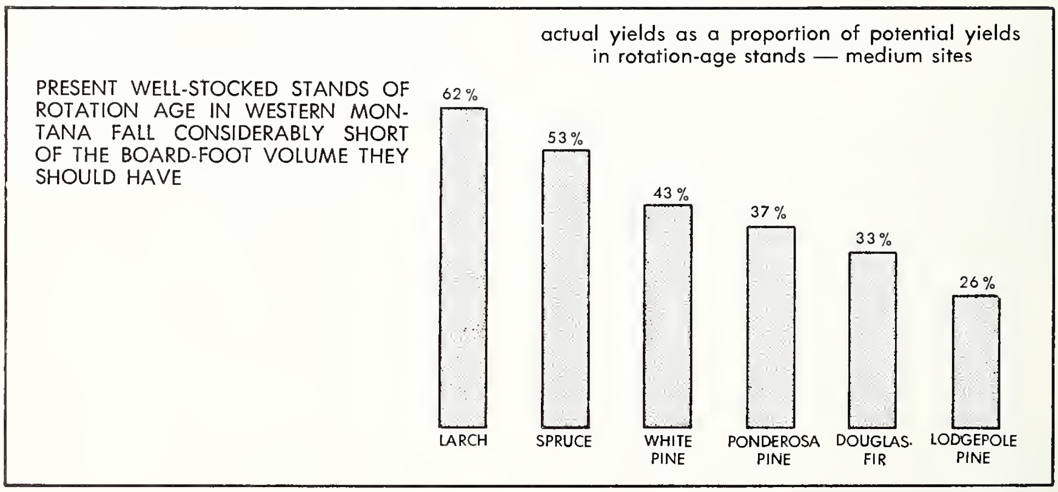

Figure 4.

Table 2.—**Reasonable tree-size objectives if tree numbers are controlled**

Species and rotation period (years)	Poor site	Medium site	Good site
	D.b.h. (inches)		
Ponderosa pine (140)	16	20	23
Western larch (140)	14	18	22
Spruce (140)	16	22	23
Douglas-fir (140)	16	19	22
Lodgepole pine (120)	12	15	17
White pine (120)	15	17	20

[1]Data do not apply to lodgepole pine growing within the white pine-cedar-grand fir zone. In this zone, lodgepole pine is short lived—maturing in about 80 years—and it probably will not produce crop trees larger than 12-15 inches even on medium and better sites.

The Value of Thinning

Forestry in this part of the country suffers from a psychological handicap because of a reputation for low productivity, not really deserved. The forest of the Northern Rocky Mountain and Intermountain Regions covers a wide climatic range—from wet to very dry, and from cold to hot. At the dry and cold extremes there is much marginal and submarginal forest from the standpoint of timber production. On the other hand, the bulk of the commercial forest has a substantial production potential (table 1). Overcrowding has been the principal obstacle standing in the way of achieving this potential.

Greatly increased harvest values could be created by thinning, assuming the volume increases mentioned in the preceding pages (fig. 5 and table 3). The opportunity in larch stands is typical. Assuming the present level of stumpage values and taking account of the effect of tree size on value, the increase in harvest yields per acre would range from $166 on poor sites to $514 on the best sites. In other words, by thinning well-stocked larch stands on good sites, we can more than double their value. On poor sites, thinning would increase the harvest value four times.

Wrapped up in the value increases shown above are the savings in processing costs that would result from handling larger trees. Experience in the Lake States Region shows that tree size greatly affects logging and manufacturing costs (fig. 6). Such data as are available indicate the curve in figure 6 is realistic also for the Northern Rocky Mountain and Intermountain Regions. The average saving in processing costs as a result of thinning, therefore, would range from $5 to $12 per thousand board feet, depending upon species and site.[8]

Any increase in per-acre yields will also tend to reduce development costs per thousand board feet. The bigger harvest yields due to thinning should lower these costs by at least 50 cents per thousand board feet on good sites, $1 on medium sites, and $1.50 on poor sites.

The reductions in the development costs and in processing costs are reflected in higher anticipated stumpage values as shown in table 3.

[8]These calculations were based on the assumptions that:
1. Thinning will increase average crop tree diameters as follows:

Poor site ....2 inches
Medium site ....3 to 4 inches
Good site ....4 to 5 inches

2. The cost of converting stands of 12-inch trees into lumber would average $60 per thousand board feet.

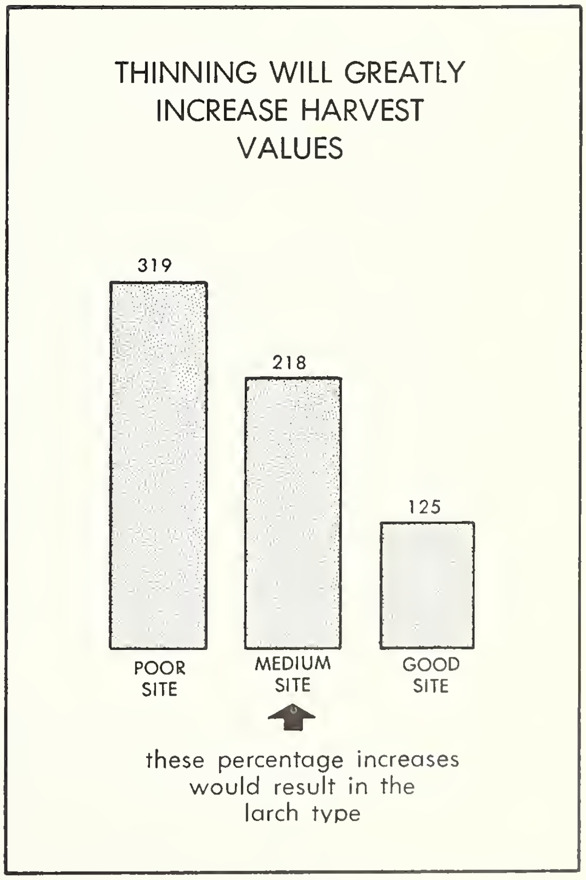

Figure 5.

Table 3. **Stumpage value of well-stocked stands with and without thinning.**

Type and rotation period (years)	Site	Without thinning Per M bd. ft.	Without thinning Per acre	With thinning Per M bd. ft.	With thinning Per acre[1]
		Dollars			
Ponderosa pine (140)	Good	15.00	285	23.30	1,028
	Medium	10.00	100	17.60	428
	Poor	6.50	26	13.40	157
Larch (140)	Good	10.00	410	17.70	924
	Medium	7.00	168	15.20	534
	Poor	4.00	52	12.10	218
Spruce (140)	Good	11.00	(2)	16.90	1,110
	Medium	7.00	182	15.20	670
	Poor	4.00	60	10.90	245
Douglas-fir (140)	Good	6.00	(2)	13.70	715
	Medium	4.50	58	12.70	446
	Poor	3.00	27	9.90	160
Lodgepole pine (120)	Good	10.00	130	18.30	642
	Medium	6.00	36	13.00	269
	Poor	2.00	8	12.50	124
White pine (120)	Good	20.00	660	31.90	2,010
	Medium	15.00	330	23.80	1,092
	Poor	10.00	(2)	17.50	551

[1]Values discounted 10 percent to allow for mortality.
[2]Insufficient sample.
Source: Developed from Forest Survey data and regional stumpage price information.

Cost of Thinning

Proper stand spacing over a period of 120 or 140 years cannot be accomplished with one or two thinnings. Most stands will have to be thinned four or five times.[9] However, every thinning after the first one, or in some cases the first two, should produce commercial-size stems. It seems safe to assume that the succeeding cuts would each produce enough value to at least cover the cost of thinning and possibly provide a profit as well. There is a certain amount of anticipation in this assumption, as it would be difficult now to market some of the smaller trees that a commercial thinning would produce. However, wood utilization is improving rapidly, and sooner or later any pole- and sawtimber-size material removed in thinnings should be marketable.

From normal yield tables, we estimate the commercial material removed in thinning will range from 2,000 to 15,000 board feet per acre over a rotation. This is 20 percent of the final harvest volume of such stands, and it is 33 to 83 percent (fig. 7) of what the **total harvest yield** would be if no thinning were done.[10]

[9]The term "thinning" is used here in a broader sense than as it is defined in most textbooks on silviculture. It includes weedings and improvement cuttings as well as cuttings made in older stands to reduce stand competition.

[10]At present, there is no information on yields possible from intermediate cuts that could be considered conclusive. In normal stands from which yield tables have been constructed, sawtimber mortality usually amounts to from 20 to 30 percent of the harvest yields. Experience gained on study plots indicates that at least this amount of volume could be captured in intermediate cuts.

The thinning problem centers in the first precommercial thinning, or for some stands, two thinnings. This precommercial thinning cannot be sidestepped because crowding begins at an early age in these forests. Yet, precommercial thinning produces no immediate revenue and is a net cost operation at an early stage in a long rotation.

Very little precommercial thinning has been done in the Northern Rocky Mountain and Intermountain Regions. For that reason, we have only limited cost data to draw upon. Figure 8 shows a range of thinning costs calculated from data from other regions. These estimates have been modified on the basis of judgment and a limited amount of local experience to take account of the more difficult terrain and more difficult accessibility in the Mountain States. We estimate costs will range from $5 to $80 an acre, depending upon number and size of trees to be removed. However, if the first thinning is done as early in the life of a stand as it should be, the per acre cost will probably range between $5 and $30.

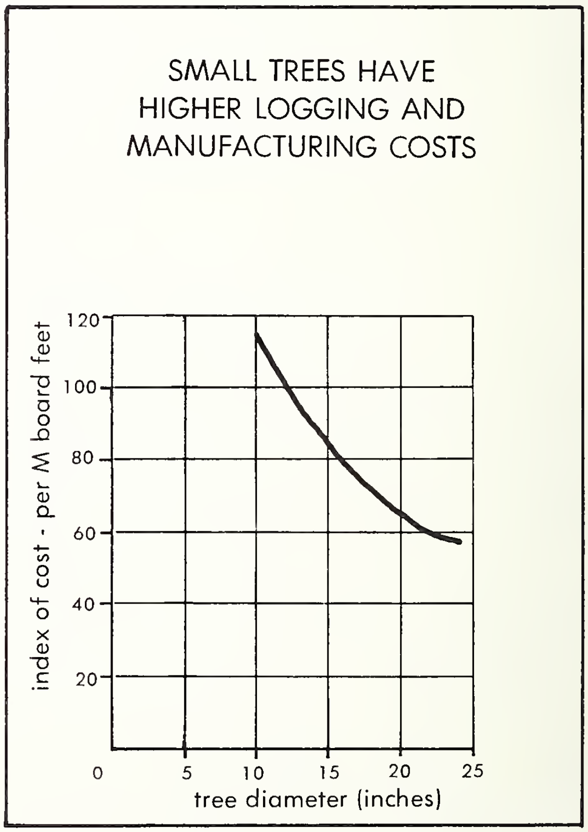

Figure 6.

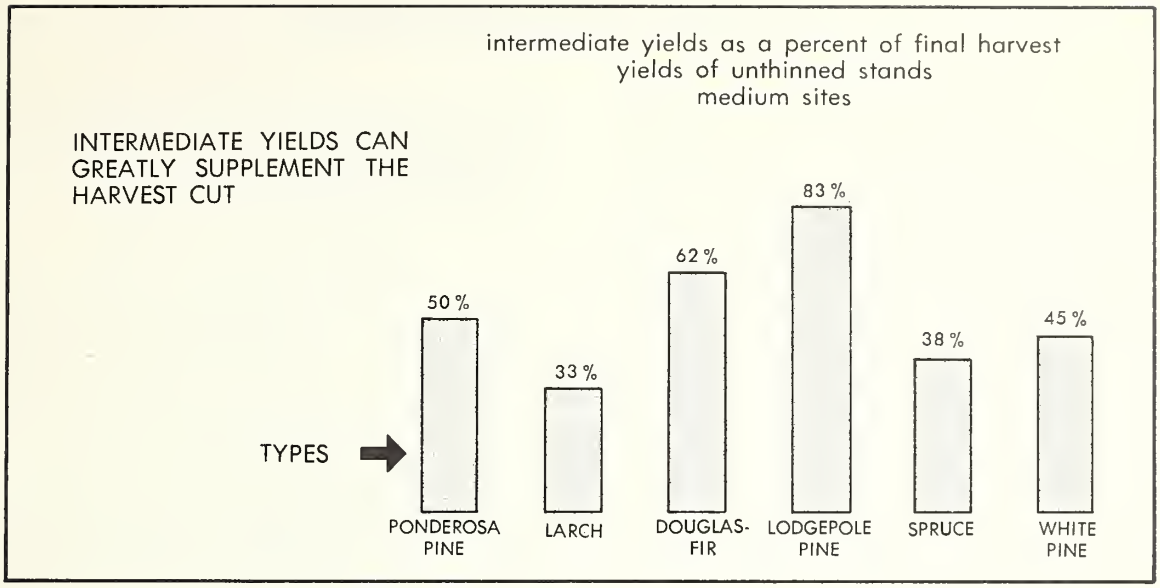

Figure 7.

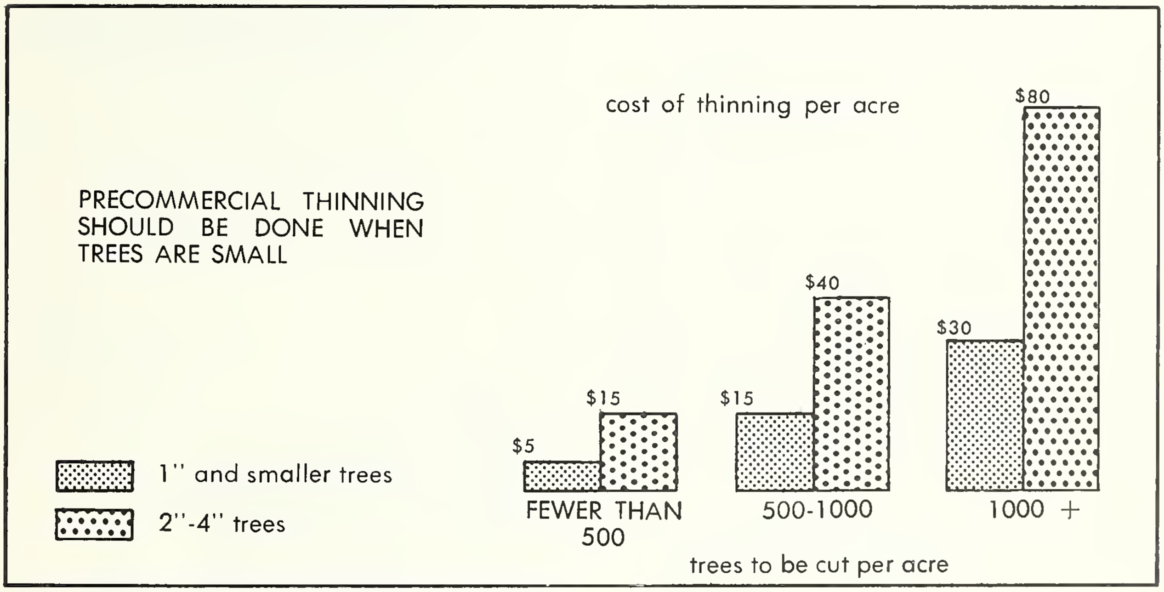

Figure 8.

Summary

If thinning is started early in the life of the stand, the ratio of cost to revenues will be the greatest. For a $5- to $30-per-acre thinning cost, harvest value yield can be increased $100 to $175 per acre on poor sites, $200 to $600 on medium sites, and $500 to more than $1,000 per acre on good sites. In addition, there should be some opportunity for profit in intermediate cuts. These figures represent the maximum opportunity. Thinning in stands that have suffered from overcrowding would, of course, return less.

THE IMPACT OF LIMB PERSISTENCE

One of the more evident contrasts between the coniferous forests of the Mountain States and those of the South is seen in the persistence of dead branches in the Mountain States. Because of a decay-inhibiting climate, this region's timber retains its dead branches long after southern trees have been naturally pruned. In the past, nature has reduced the effect of limb persistence in our virgin stands by long rotations. Even so, the percentage of clear lumber produced from Mountain States logs has been relatively low. In northern Idaho, western Montana, and northeastern Washington, for example, D-select and better boards make up only 2 to 15 percent of the total lumber sold, according to the following tabulation developed from price and sales data from Region 1:

	Percent
Ponderosa pine	15
Spruce	6
Larch and Douglas-fir	10
Lodgepole pine	2
White pine	12

The virgin longleaf pine of the South, by contrast, probably averaged more than 25 percent clear wood.[11]

As rotations are shortened, the problem of limb persistence will become more critical if the emphasis on clear wood is to continue. We can get some idea of the future problem from log grade data. Forest Survey statistics for western Montana show that butt logs of only 25 percent of the **rotation-age** ponderosa pine trees of saw-log size are sufficiently limb- and knot-free to qualify as "clear" (grade number 1).[12] On the other hand, 21 percent of these butt logs are "low common" (grade number 4). Practically no spruce or lodgepole pine logs of rotation age are knot- and limb-free (table 4).

Table 4.—**Quality of butt logs of rotation-age trees of crop-tree size in natural stands, western Montana**

Log grade	Ponderosa pine	Lodgepole pine	Spruce
	Percent		
Number 1—surface clear	25	0	0
Number 2—50 percent surface clear	29	42	60
Number 3—common	25	33	40
Number 4—low common	21	25	0
Total	100	100	100

Source: Forest Survey data.

[11]Bryant, Ralph Clement. Lumber. 539 pp. New York. 1922.

[12]The log grades referred to in this report are the four grades used by the Forest Survey in this area.

Opportunity for Pruning

In this circumstance, pruning becomes an important means of increasing the value yield for those species for which clear wood has or will have a premium value. The four soft-textured softwoods (white pine, ponderosa pine, lodgepole pine, and spruce), which occupy about 60 percent of the commercial forest area in these two regions, certainly are in this category. Clear lumber of these species is currently worth from about $53 to $90 (50

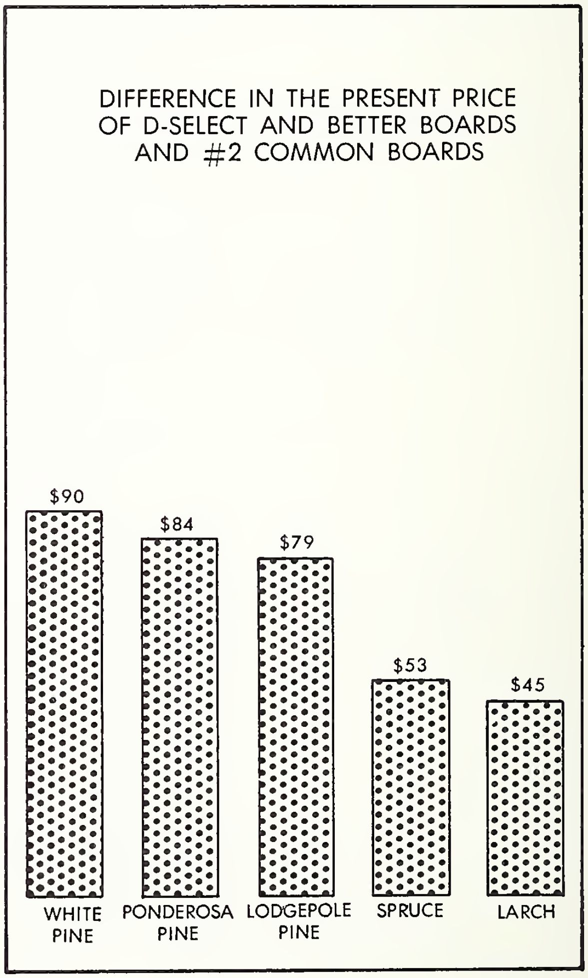

Figure 9.

to 80 percent) more per thousand board feet than number 2 common lumber (fig. 9).

Larch also can apparently be pruned advantageously even though it is a hard-textured softwood. This high-strength wood has special value for such structural purposes as laminated beams, and it is becoming increasingly popular as a decorative paneling. The spread in value between D-select and number 2 common larch boards is now only about $45 per thousand board feet. However, experts in forest utilization believe the quality advantage of this species is yet to be fully exploited.

The physical gains from pruning will depend on three things: how well the pruning is done; the size of the tree when pruned; and its size when cut. The potential pruning opportunity is best when trees are young (fig. 10). For example, if a tree is pruned when it is 4 inches in diameter and logged when it is 12 inches, the butt log will produce 50 percent clear wood. If it is pruned at 4 inches and allowed to grow to 22 inches, the butt log will have 87 percent clear wood. In any forest where pruning is done at the appropriate stage in the development of each stand, D-select and better lumber might easily make up the following percentages of the final harvest yields in contrast with the 2 to 15 percent recovery in stands now being cut:

	Percent
Ponderosa pine	35
Larch	19
Spruce	34
Lodgepole pine	25
White pine	28

Value of Pruning

How important the improvement in grade recovery will ultimately prove to be will depend largely upon the trend of wood values. These need to be studied in greater detail than they have been heretofore. At present the lumber market is changing because of the impact of competitive materials. The effect clear wood is likely to have on the use and value of plywood in the future is also a factor. If we accept the Forest Service's Timber Resource Review estimates at face value, knot-free or clear wood will be in even shorter supply in the future than it is today.[13] Thus, the value increase from pruning may be greater than present prices indicate.

However, even if it is assumed that the price spread due to difference in quality will never increase, pruning will increase log values by about 50 percent. In other words, the butt log of a pruned tree will be worth about 50 percent more than a comparable unpruned log. Table 5 shows the value increases likely to occur for typical logs of the several species.[14]

[13] U. S. Forest Service. Op. cit. pp. 404-5.

[14] Theoretical pruning yields, like theoreticol mink farm yields, should be viewed with o certoin amount of caution. It is eosy to be corried away by figures. As o hedge ogoinst such over-optimism, the doto in toble 5 include severol foctors of conservotism. In the first place, fairly large knotty cores were ossumed far the lorger pruned trees, which tends to discount the clear-waod yield. It wos ossumed that the knotty core of pruned logs would range from 6 inches in 12-inch trees to 10 inches in 22-inch trees.

In the second ploce, it wos assumed thot the composition af the select grode lumber would be obout the same as now. Actuolly, pruned logs shauld produce relotively more B-select lumber ond less D-select lumber than present grode 1 logs. In oddition, a discount wos applied to allow for losses thot will occur between time of pruning and time of harvest.

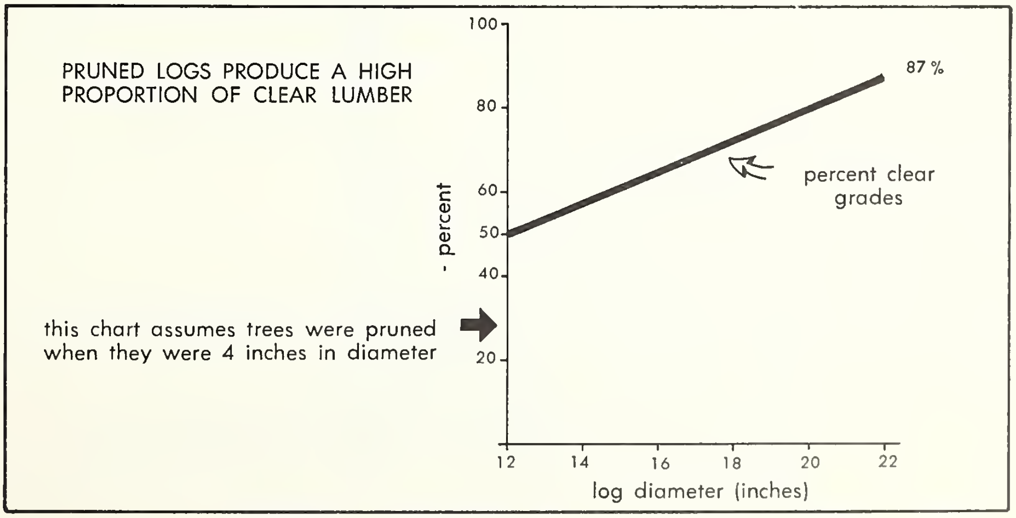

Figure 10.

Toble 5.—**Value per thousand board feet of lumber produced from pruned and unpruned logs**

Species	Averoge log diameter	Conversion volue	
		Not pruned	Pruned
	Inches	Dollars	
Ponderaso pine	20	112	166
Larch	19	80	118
Spruce	19	82	127
Lodgepole pine	15	90	140
White pine	18	130	190

Cost of Pruning

Like thinning, pruning is not cheap. It costs about 40 cents to prune the first log of a tree. Assuming that 20 percent of the pruned trees will fall by the wayside before the final harvest, the cost per crop tree harvested will be 50 cents. In current practice, where release cutting is done in conjunction with pruning, the total operation costs from 70 to 75 cents a tree. Assuming a 20-percent allowance for losses and premature harvesting, the cost in this case would be about 90 cents for each harvested tree. These 50- and 90-cent estimates reflect the fact that good pruning involves more than a hurried job of slashing at branches with an ax or club, leaving broken stubs and gouged tree trunks when the aim is poor. Good pruning is an exacting job that takes time.

Pruning is likely to cost from $30 to $92 per acre (table 6), depending primarily upon the number of trees pruned. The low costs are on the best sites where the crop trees would be larger and fewer per acre.

Toble 6.—**Estimated cost of pruning, by type and site**

Species	Site	Trees pruned[1] per acre	Pruning cost[2] per ocre
		Number	Dollars
Ponderosa pine	Good	59	30
	Medium	66	33
	Poor	83	42
Lorch	Good	86	43
	Medium	106	53
Spruce	Good	77	38
	Medium	70	35
	Poor	100	50
Lodgepole pine	Goad	110	55
	Medium	104	52
White pine	Good	110	55
	Medium	148	74
	Poor	184	92

[1]Assuming 75 percent of normol stacking at time of horvest.
[2]Pruning cost averages about 40 cents per tree. This cost wos increased 25 percent to toke account of trees pruned that never reached rototion oge.

Summary

Pruning is a more expensive measure than precommercial thinning. However, if the present difference in wood price due to quality continues, pruning offers a substantial opportunity to increase value yield. This is particularly true if the pruning effort is concentrated on the more valuable species growing on the better sites. Less than a dollar spent per tree to prune the first log should result in a $5 to $10 higher conversion value for the tree.

COMPOSITE EFFECT OF THINNING AND PRUNING

To a certain extent, thinning and pruning have a ham-and-eggs relationship. Almost any well-stocked stand that is to be pruned must be thinned for the pruning to be effective. Likewise, pruning is an important adjunct to thinning because the benefit/cost ratio for pruning is usually about 25 percent to 100 percent higher than for thinning. Consequently, the desirability of thinning is enhanced if it is accompanied by pruning.

Figure 11 suggests the value increases that would result from thinning and pruning in five timber types, and from thinning alone in the Douglas-fir type. These data apply to well-stocked stands on medium sites. The actual dollar values used are contained in table 7. To avoid misinterpretation of these data, we repeat the major assumptions that underlie them:

1. It will be possible to achieve 75 percent utilization of the growing space at rotation age on each treated acre that is harvested.
2. Mortality losses will amount to 10 percent of harvest yields.
3. Cost-price relationship will not change.

The most difficult assumption is probably that regarding mortality. Whether the volume yields shown for thinned stands can be maintained over broad areas is subject to question. However, because the mortality data available are totally inadequate for use in predicting yields, it is necessary to rely completely on this assumption, which has no other defense than that it seems reasonable.

In any case, it is apparent that in the lodgepole pine type, and to a lesser extent in the other types, thinning has two important effects:

- It permits the crop trees in productive stands to grow larger.
- It prevents stands from becoming nonproductive through stagnation before the trees reach usable size.

Figure 11 illustrates the contribution that thinning and pruning could make to forest productivity in the Northern Rocky Mountain and Intermountain Regions. Together, they could increase value yields of well-stocked stands by 400 percent or more.

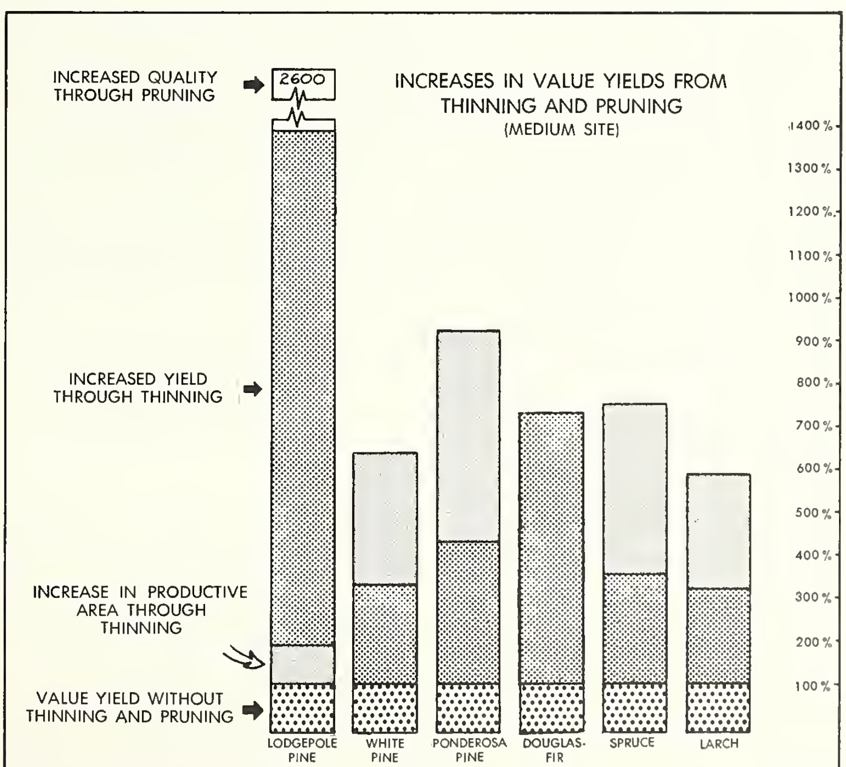

Figure 11.

Table 7.—**Per acre value yields of well-stocked natural stands compared with value yields of thinned and pruned stands**

Species	Site	Average value yields		
		No thinning or pruning	Thinned[1]	Thinned[1] and pruned
		Dollars		
Ponderoso pine	Good	285	1,028	1,984
	Medium	100	428	963
	Poor	26	157	456
Western lorch	Good	410	924	1,698
	Medium	168	534	1,011
	Poor	52	218	([3])
Spruce	Good	—	1,111	2,151
	Medium	182	670	1,426
	Poor	60	245	605
Douglos-fir	Good	—	715	([3])
	Medium	58	446	([3])
	Poor	27	160	([3])
Lodgepole pine	Good	130	642	1,434
	Medium	18[2]	269	737
	Poor	8	124	([3])
White pine	Good	660	2,010	3,396
	Medium	330	1,092	2,158
	Poor	—	551	1,545

[1]Volues hove been discounted 10 percent to ollow for mortolity.
[2]Discounted 50 percent for oreo thot will not grow sowtimber-size trees.
[3]Thinning only.

EVALUATION OF THINNING AND PRUNING

Properly executed programs of thinning and pruning eventually will substantially improve both the volume and quality of timber yields. If present cost and value levels continue, each dollar spent in thinning will produce $4 to $45 in added yields. Under the same circumstances, each dollar spent in pruning would produce $9 to $40 of extra benefit.

The difficulty, of course, lies in the long time span between the pruning of precommercial thinning and the harvest. Just when these operations should be done varies with individual stands. However, with the rotations indicated in the preceding pages, the precommercial thinning will probably be done 80 to 120 years before the end of the rotation. The time span in pruning will probably be 70 to 100 years.

If the justification for thinning and pruning is to be based on a comparison of costs with discounted values stand by stand, the relatively high rate of physical return will be largely nullified by the time factor. Table 8 indicates the rates of return that might be expected in the six most important types in these two regions with this kind of discounting. The significant point is that **only the most valuable species on the best sites would return rates that are currently thought to be reasonable for long-term investment.** There is, of course, relatively little of this top-site area.

Table 8.—**Interest rates thinning and pruning would produce if the value increases on each acre are matched with the costs on that acre**

PONDEROSA PINE

Assuming a 140-year rotation, precommercial thinning at 20 - 40 years, and pruning at 40 - 60 years.

Interest return on investment acre by acre	Percent
Good site	3.2
Medium site	2.6
Poor site	2.0

LARCH

Assuming a 140-year rotation, precommercial thinning at 20 - 40 years, and pruning at 40 - 50 years.

Interest return on investment acre by acre	
Good site	2.7
Medium site	2.4
Poor site	1.7

SPRUCE

Assuming a 140-year rotation, precommercial thinning at 20 - 40 years, and pruning at 40 - 60 years.

Interest return on investment acre by acre	
Good site	([1])
Medium site	3.0
Poor site	2.2

[1]Incomplete data.

DOUGLAS-FIR[2]

Assuming a 140-year rotation, and precommercial thinning at 20 - 40 years. No pruning.

Interest return on investment acre by acre	Percent
Good site	([1])
Medium site	2.3
Poor site	1.5

LODGEPOLE PINE

Assuming a 120-year rotation, precommercial thinning at 20 - 40 years, and pruning at 30 - 50 years, and a 50-percent increase in productive area.

Interest return on investment acre by acre	
Good site	3.0
Medium site	2.6
Poor site	1.7

WHITE PINE

Assuming a 120-year rotation, precommercial thinning at 20 - 30 years, and pruning at 30 - 50 years.

Interest return on investment acre by acre	
Good site	3.8
Medium site	3.3
Poor site	([1])

[2]Thinning only.

The data in table 8 merely emphasize a point that is already generally recognized. **There is virtually no place in long-rotation forestry for the owner with bare ground or a single-age-class property.** This situation is not unique because there is no place in the competitive business atmosphere of today for the enterprise faced with an imbalance between cost and income for a long time. Moreover, even the owner with a reasonably balanced or manageable distribution of age classes will see little opportunity if he weighs the cost of managing each acre against the discounted revenues from that acre.

However, the owner blessed with a manageable distribution of age classes (such as is found in the national forests or on larger industrial acreages) probably will not turn to this type of calculation for a measure of the attractiveness of the business venture or for a means of evaluating alternatives. He will be chiefly interested in the over-all soundness of the total operation, taking account of the costs associated with managing his resource.

His first concern will be to determine what level of costs will be required to achieve the objectives of the enterprise. Presumably, the objective usually will be to increase the productivity of the whole operation and to achieve the best ultimate balance between cost and revenue. The preceding calculations leave no doubt that thinning and pruning offer an excellent way to do this.

His second concern with expenditures will be how much thinning and pruning expense can be borne by current revenues. The answer to this question will vary with each individual owner, depending upon income and cost prospects and his objectives of management.

The public evaluation of cost-to-revenue relationships will, of course, be both broader and more involved than for private holdings. It will be broader because the timber management objective of public forest ownerships is essentially to help supply a national wood need and at the same time provide the resource for a substantial expansion of employment. Beyond that there is also the responsibility to accomplish these objectives as economically as possible.

The case for thinning and pruning on properties having a reasonably balanced growing stock rests on three facts:

- Both measures will greatly increase the quantity and quality of utilizable wood in the long run.
- They will provide the opportunity for expanded employment in years to come.
- They represent one of the best means available for increasing forestry operating margins in the Northern Rocky Mountain and Intermountain Regions.

If greater volume and value yields are to be achieved, a substantial effort in thinning and pruning will be necessary, for these measures are basic to a buildup of productivity and value yield. Fortunately, the ultimate payoff from both thinning and pruning will be large.

The Intermountain Forest and Range Experiment Station, U. S. Forest Service, has headquarters in Ogden, Utah, and maintains research centers at:

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